US009855704B2

(12) **United States Patent**
Miyano et al.

(10) **Patent No.: US 9,855,704 B2**
(45) **Date of Patent: Jan. 2, 2018**

(54) **POWDER RECOATER**

(71) Applicant: **TECHNOLOGY RESEARCH ASSOCIATION FOR FUTURE ADDITIVE MANUFACTURING**, Tokyo (JP)

(72) Inventors: **Hideaki Miyano**, Yokohama (JP); **Yoshikazu Ooba**, Yokohama (JP); **Yousuke Katou**, Yokohama (JP); **Koukichi Suzuki**, Yokohama (JP); **Yuya Daicho**, Yokohama (JP)

(73) Assignee: **TECHNOLOGY RESEARCH ASSOCIATION FOR FUTURE ADDITIVE MANUFACTURING**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/760,134**

(22) PCT Filed: **Feb. 27, 2015**

(86) PCT No.: **PCT/JP2015/055964**
§ 371 (c)(1),
(2) Date: **Jul. 9, 2015**

(87) PCT Pub. No.: **WO2016/135974**
PCT Pub. Date: **Sep. 1, 2016**

(65) **Prior Publication Data**

US 2016/0311164 A1 Oct. 27, 2016

(51) **Int. Cl.**
B29C 67/00 (2017.01)
B29C 64/329 (2017.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B29C 64/329*** (2017.08); ***B05D 1/12*** (2013.01); ***B22F 3/105*** (2013.01); ***B28B 13/02*** (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,988,096 A * 10/1976 Papalexis A21C 11/10 222/340
4,503,995 A * 3/1985 Anderson A21C 5/04 222/219
(Continued)

FOREIGN PATENT DOCUMENTS

JP 7-76026 A 3/1995
JP 2000-117721 A 4/2000
(Continued)

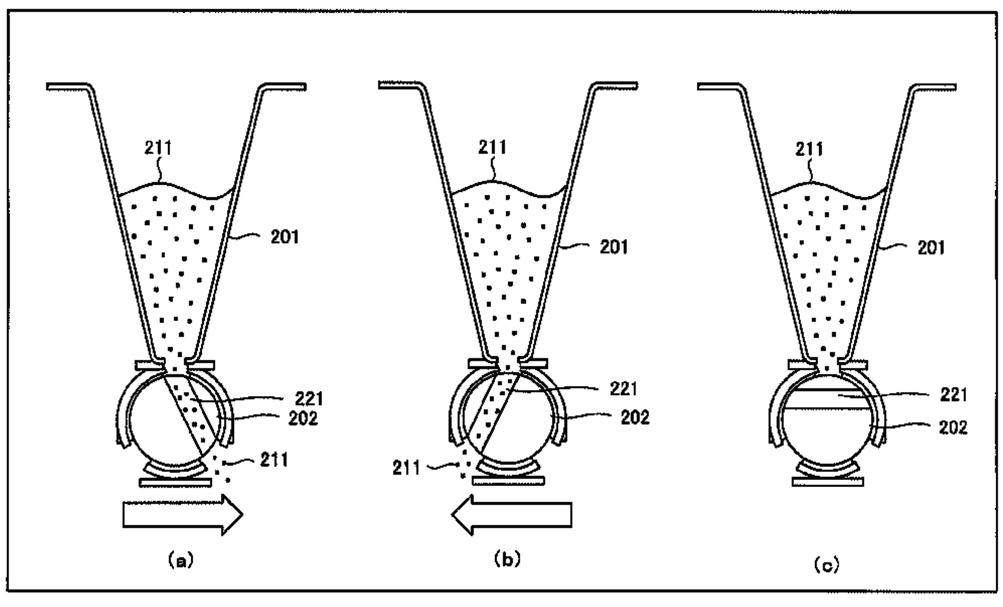
OTHER PUBLICATIONS

International Search Report dated Jun. 11, 2015 for Application No. PCT/JP2015/055964.
(Continued)

Primary Examiner — Matthew Daniels
Assistant Examiner — Manley L Cummins, IV
(74) *Attorney, Agent, or Firm* — Ladas & Parry LLP

(57) **ABSTRACT**

A powder is spread in two directions, that is, the advancement and retraction directions of a powder recoater. The powder recoater according to this invention includes a hopper that stores a powder, and a cylindrical powder supplier that has a side surface close to or in contact with the bottom surface of the hopper and includes a supply path for the powder. The powder recoater according to this invention further includes a pivoting unit that causes the powder
(Continued)



supplier to pivot. In the powder recoater according to this invention, the center axis of the supply path is displaced from the center axis of the powder supplier in the radial direction of the powder supplier.

10 Claims, 5 Drawing Sheets

(51) **Int. Cl.**

B29C 64/255	(2017.01)
B29C 64/165	(2017.01)
B29C 64/153	(2017.01)
B22F 3/105	(2006.01)
B29C 31/02	(2006.01)
B28B 13/02	(2006.01)
B33Y 30/00	(2015.01)
B33Y 10/00	(2015.01)
B05D 1/12	(2006.01)
B29C 64/343	(2017.01)

(52) **U.S. Cl.**

CPC ***B29C 31/02*** (2013.01); ***B29C 64/153*** (2017.08); ***B29C 64/165*** (2017.08); ***B29C 64/255*** (2017.08); ***B29C 67/00*** (2013.01); ***B33Y 10/00*** (2014.12); ***B33Y 30/00*** (2014.12); *B29C 64/343* (2017.08)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,954,301	A *	9/1990	Saeki	B29C 45/76 264/328.4
5,071,337	A *	12/1991	Heller	B29C 64/135 118/603
5,204,055	A *	4/1993	Sachs	B05C 19/04 264/113
5,213,817	A *	5/1993	Pelley	A61F 13/15658 118/308
5,344,299	A *	9/1994	Takeuchi	B29C 31/048 264/142
5,387,380	A *	2/1995	Cima	B05C 19/04 264/109
5,647,931	A *	7/1997	Retallick	B22F 3/004 156/273.3
5,934,343	A *	8/1999	Gaylo	B22F 3/004 141/12
6,213,168	B1 *	4/2001	Gaylo	B22F 3/004 141/12
7,799,253	B2 *	9/2010	Hochsmann	B29C 64/153 118/308
2006/0105102	A1 *	5/2006	Hochsmann	B05D 1/26 427/180
2006/0204603	A1 *	9/2006	Leuterer	B29C 64/153 425/174.4
2006/0214335	A1 *	9/2006	Cox	B01F 3/188 264/497
2006/0214355	A1 *	9/2006	Fukao	B65H 3/0661 271/10.11
2008/0006334	A1 *	1/2008	Davidson	B29C 64/35 137/571
2008/0260945	A1 *	10/2008	Ederer	B05C 19/04 427/212
2009/0011066	A1 *	1/2009	Davidson	B29C 41/12 425/215
2011/0015416	A1 *	1/2011	Ueyama	A23D 9/00 554/63
2012/0097258	A1 *	4/2012	Hartmann	B29C 64/20 137/14

FOREIGN PATENT DOCUMENTS

JP	2005-81174	A	3/2005
JP	2014-188758	A	10/2014
WO	WO 2005/080010	A1	9/2005
WO	WO 2010/149133	A1	12/2010

OTHER PUBLICATIONS

J-PlatPat English abstract of JP JP 2014-188758 A.
J-PlatPat English abstract of JP JP 2005-81174 A.
J-PlatPat English abstract of JP JP 7-76026 A.
J-PlatPat English abstract of JP JP 2000-117721 A.

* cited by examiner

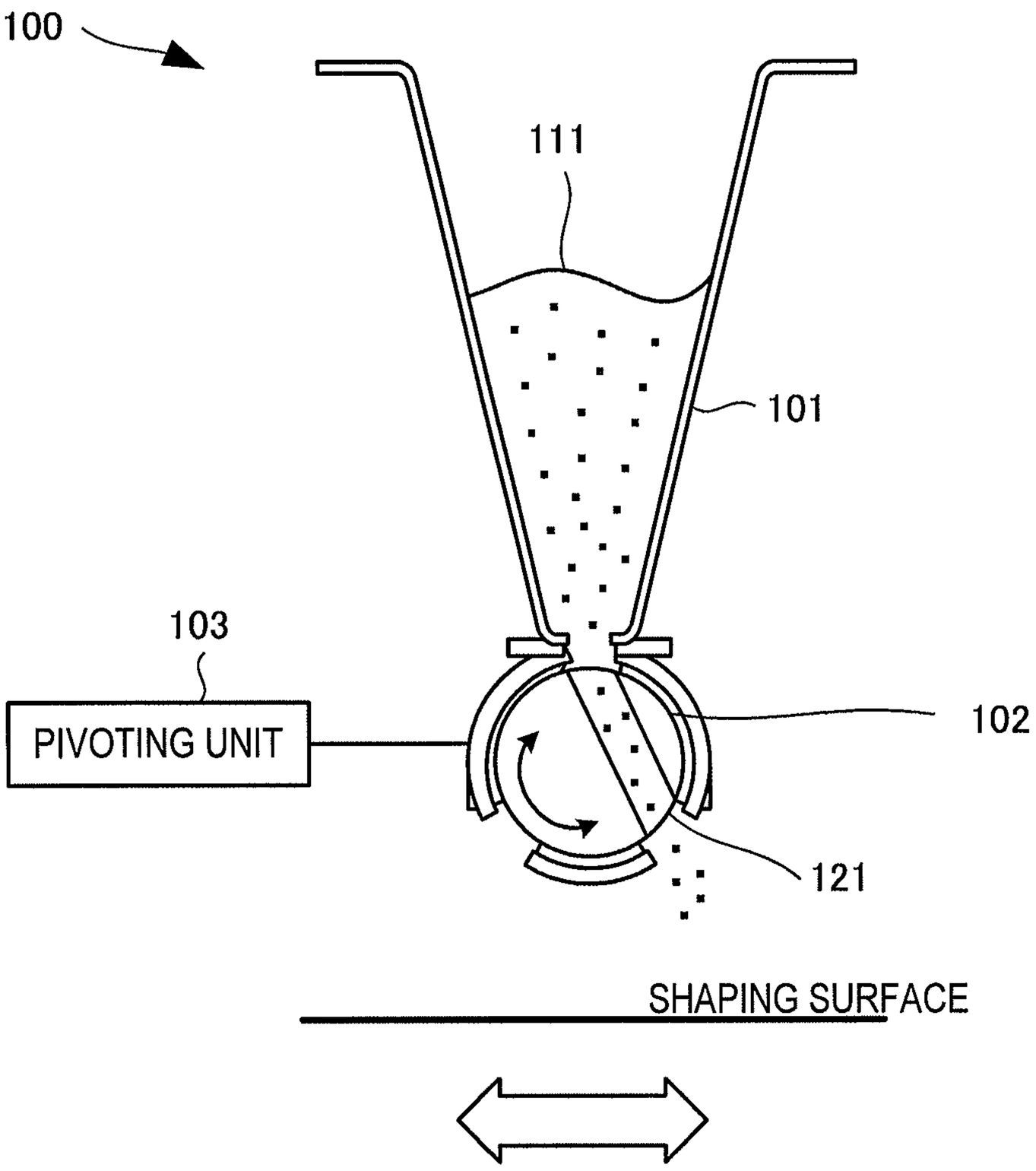


FIG. 1

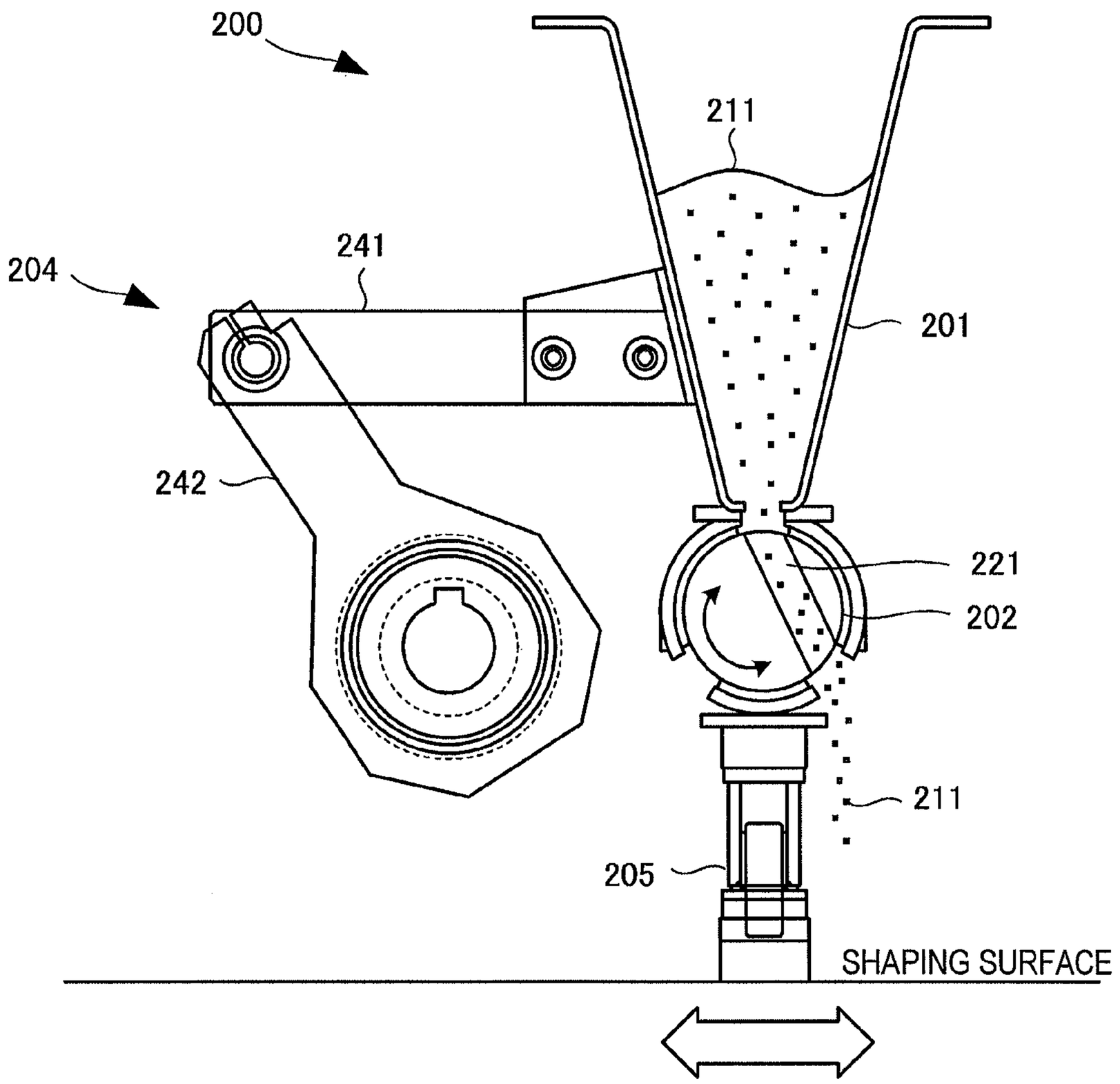


FIG. 2

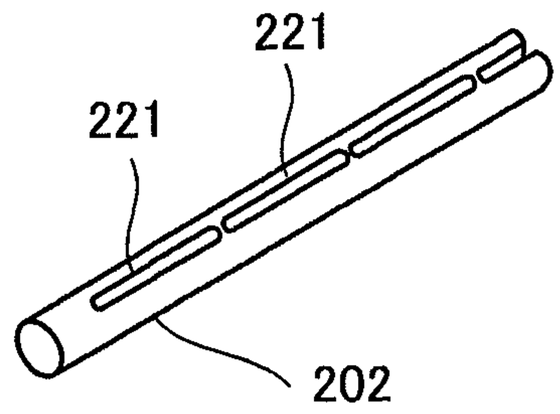


FIG. 3

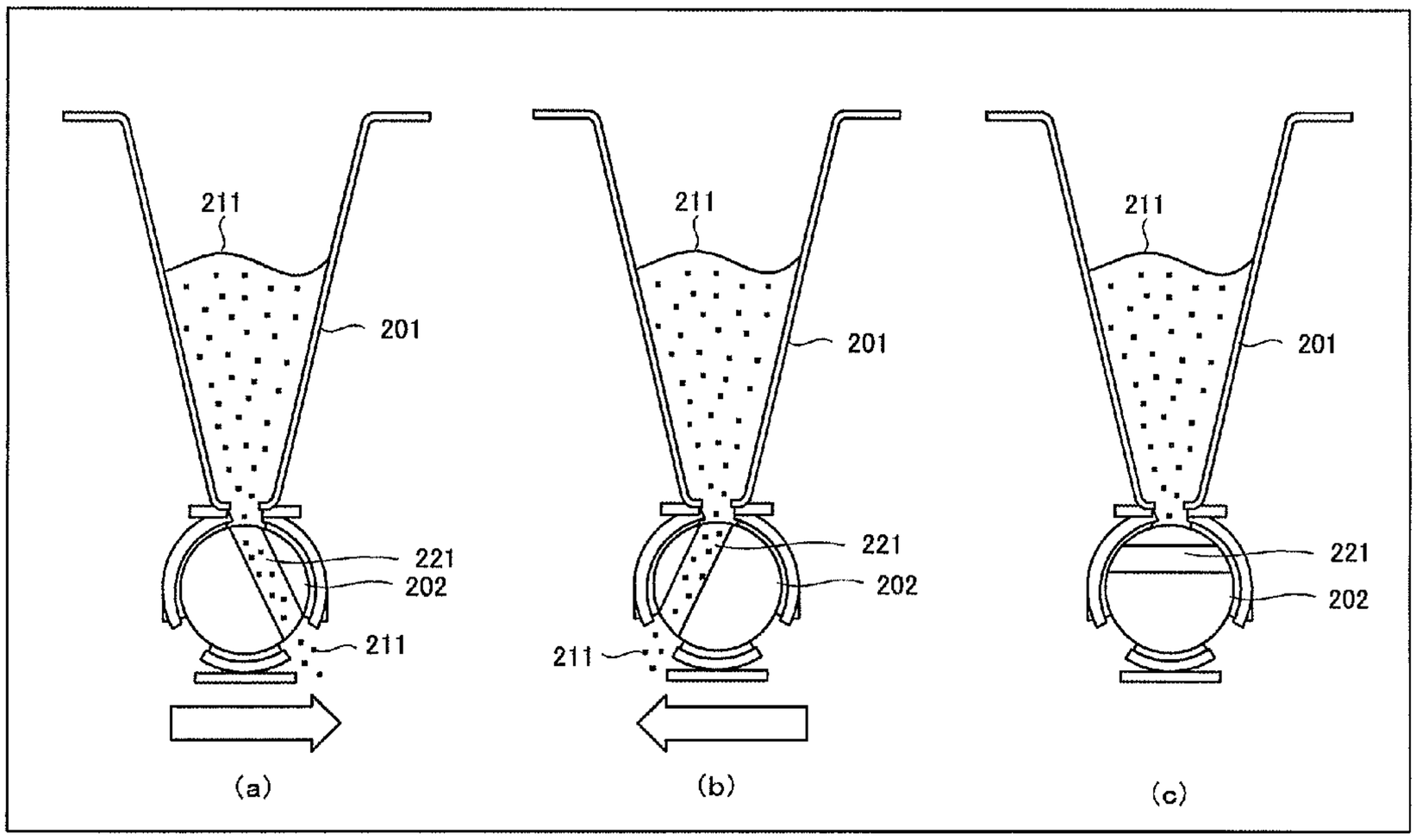


FIG. 4

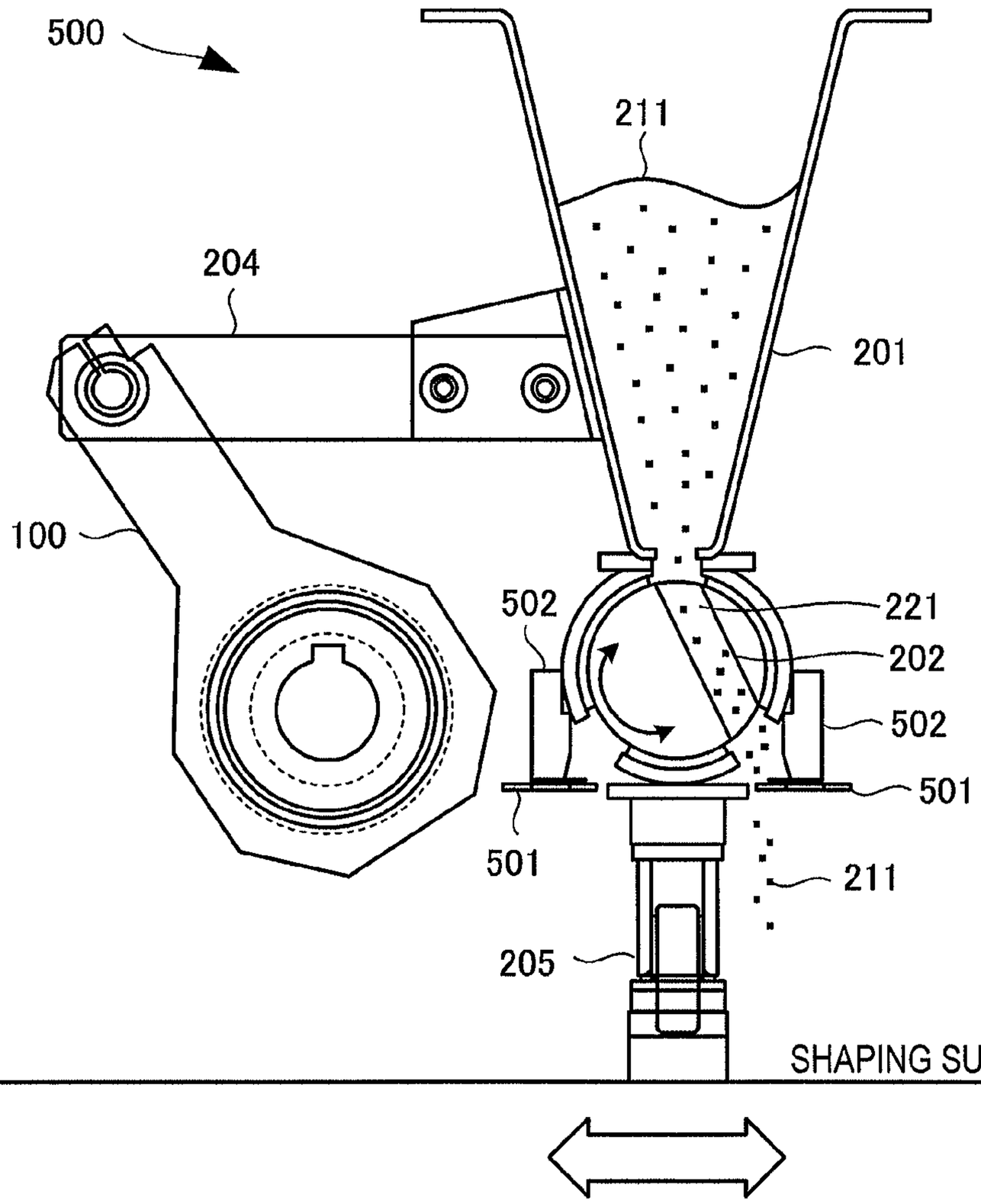

500
211
204
201
100
502
221
202
502
501
501
211
205
SHAPING SURFACE

FIG. 5

POWDER RECOATER

TECHNICAL FIELD

The present invention relates to a powder recoater.

BACKGROUND ART

In the above technical field, patent literature 1 discloses a technique of vibrating a recoater and spreading a powder. Patent literature 2 discloses a technique of, when spreading a powder, applying a positive pressure to a recoater, and when stopping the spread of the powder, applying a negative pressure to the recoater.

CITATION LIST

Patent Literature

Patent literature 1: International Publication WO 2005/080010

Patent literature 2: International Publication WO 2010/149133

SUMMARY OF THE INVENTION

Technical Problem

In the techniques described in these literatures, however, a powder can be spread in only one direction, for example, the advancement direction of the powder recoater, and the powder cannot be spread in two directions, that is, the advancement and retraction directions of the powder recoater.

The present invention enables to provide a technique of solving the above-described problem.

Solution to Problem

One aspect of the present invention provides a powder recoater comprising:

a hopper that stores a powder;

a cylindrical powder supplier that has a side surface close to or in contact with a bottom surface of the hopper and includes a supply path for the powder; and

a pivoting unit that causes the powder supplier to pivot,

wherein a center axis of the supply path is displaced from a center axis of the powder supplier in a radial direction of the powder supplier.

Advantageous Effects of Invention

According to the present invention, a powder can be spread in two directions, that is, the advancement and retraction directions of the powder recoater.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view showing the arrangement of a powder recoater according to the first embodiment of the present invention;

FIG. **2** is a side view showing the arrangement of a powder recoater according to the second embodiment of the present invention;

FIG. **3** is a perspective view showing the powder supply portion of the powder recoater according to the second embodiment of the present invention;

FIG. **4** shows the states of spreading a powder by the powder recoater according to the second embodiment of the present invention; and

FIG. **5** is a side view showing the arrangement of a powder recoater according to the third embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the drawings. It should be noted that the relative arrangement of the components, the numerical expressions and numerical values set forth in these embodiments do not limit the scope of the present invention unless it is specifically stated otherwise.

First Embodiment

A powder recoater **100** according to the first embodiment of the present invention will be described with reference to FIG. **1**. The powder recoater **100** is a device that spreads a powder **111** to a fabricating surface while moving left and right on the fabricating surface.

As shown in FIG. **1**, the powder recoater **100** includes a hopper **101**, a powder supply portion **102**, and a pivoting unit **103**. The hopper **101** stores the powder **111**. The powder supply portion **102** has a side surface close to or in contact with the bottom surface of the hopper **101**. The powder supply portion **102** has a supply path **121** for the powder **111**, and has a cylindrical shape. The center axis of the supply path **121** is displaced from the center axis of the powder supply portion **102** in the radial direction. The pivoting unit **103** causes the powder supply portion **102** to pivot.

According to the first embodiment, the powder supply portion **102** pivots, and the powder **111** can be spread in two directions, that is, the advancement and retraction directions of the powder recoater.

Second Embodiment

A powder recoater **200** according to the second embodiment of the present invention will be described with reference to FIGS. **2** to **4**. FIG. **2** is a view for explaining the arrangement of the powder recoater **200** according to this embodiment. FIG. **3** is a perspective view showing a powder supply portion **202** of the powder recoater **200** according to this embodiment.

The powder recoater **200** is a device that spreads a powder **211** to a fabricating surface while moving left and right on the fabricating surface. The powder recoater **200** includes a hopper **201**, the powder supply portion **202**, a swing portion **204**, and a smoothing portion **205**. Further, the powder recoater **200** includes a pivoting unit such as a servo motor (not shown).

The hopper **201** stores the powder **211** that is spread to the fabricating surface. Before spreading, the powder **211** is properly supplied in a predetermined amount from, for example, a tank (not shown) that stores the powder **211**, and replenishes the hopper **201**. The powder **211** is input from an input port at the top of the hopper **201**, and supplied to the powder supply portion **202** from a discharge port provided in the bottom surface.

The powder supply portion **202** is provided near the bottom surface of the hopper **201**, or provided in contact with the bottom surface. The powder supply portion **202** is a cylindrical member, and a supply path **221** through which the powder **211** passes is provided in the side surface. The

supply path **221** is provided so that the center axis of the supply path **221** is displaced and shifted from the center axis of the cylindrical powder supply portion **202** in the radial direction of the powder supply portion **202**. The center axis of the supply path **221** is decentered from the center axis of the powder supply portion **202**.

The supply path **221** is formed by providing a plurality of holes so as to form a slit, but may be formed from a single hole (single slit). The supply path **221** may also be formed by connecting a plurality of members each having a single hole.

The supply path **221** can have any shape as long as the powder **211** can pass, and can have various shapes such as a circle, ellipse, polygon, and slit. A pivoting mechanism (not shown) such as a servo motor is attached to the powder supply portion **202**, and the powder supply portion **202** pivots along with the operation of the servo motor. The powder supply portion **202** can be made of an arbitrary material such as a metal (for example, aluminum, iron, or copper), a plastic, or a resin.

By changing the orientation of the discharge port of the supply path **221** of the powder supply portion **202**, the powder **211** can be spread regardless of whether the traveling direction of the powder recoater **200** is the advancement direction or the retraction direction. Since the powder **211** can be spread even in the backward direction, the fabricating time can be shortened.

The swing portion **204** swings the hopper **201** to apply vibrations to the hopper **201** and promote supply of the powder **211** to the supply path **221** of the powder supply portion **202**. The swing portion **204** includes a swing arm **241** and a rotation arm **242**. The swing arm **241** is connected to the hopper **201**. The rotation arm **242** is decentered from the center of rotation. Vibrations generated by rotation of the rotation arm **242** are transferred to the swing arm **241**, thereby applying the vibrations to the hopper **201** and promoting the drop of the powder **211**.

The smoothing portion **205** smooths the powder **211** spread to the fabricating surface. The powder **211** spread from the powder supply portion **202** drops from the supply path **221** of the powder supply portion **202**, and its thickness is not uniform (constant) in a state in which the powder **211** is spread to the fabricating surface. The smoothing portion **205** thus smooths the surface of the powder **211**. For example, the powder **211** may be tapped or smoothed by a roller or the like. After the powder **211** is smoothed, it is irradiated by a laser or the like and hardened, manufacturing a three-dimensional shaped object.

FIG. **4** shows the states of spreading the powder **211** by the powder recoater **200** according to this embodiment. In FIG. **4**, (*a*) is a view showing a state in which the powder **211** is spread in the advancement direction. In FIG. **4**, (*b*) is a view showing a state in which the powder **211** is spread in the retraction direction. In FIG. **4**, (*c*) is a view showing a state in which the spread of the powder **211** is stopped.

When the powder recoater **200** advances rightward (advancement direction or forward direction) on the paper surface, as shown in (a) of FIG. **4**, the discharge port of the supply path **221** of the powder supply portion **202** is positioned right.

In contrast, when the powder supply portion **202** advances leftward (retraction direction or backward direction) on the paper surface, as shown in (b) of FIG. **4**, the discharge port of the supply path **221** of the powder supply portion **202** is positioned left.

By controlling the position of the discharge port of the supply path **221** of the powder supply portion **202**, the powder **211** can be spread ahead in the traveling direction of the powder recoater **200**.

When stopping the supply of the powder **211**, as shown in (c) of FIG. **4**, the powder supply portion **202** pivots to position the discharge port of the hopper **201** and the supply path **221** so that they do not communicate straight.

In this manner, the position where the supply path **221** is provided is set at a position shifted in the radial direction from the center axis of the powder supply portion **202**. The powder **211** can be spread regardless of whether the powder recoater **200** moves ahead or back.

According to the second embodiment, the fabricating speed is increased because the powder **211** can be spread not only when the powder recoater **200** moves in the traveling direction, but also when it moves in the retraction direction. The powder recoater **200** according to the second embodiment can also be used for a three-dimensional fabricating apparatus.

Third Embodiment

A powder recoater according to the third embodiment of the present invention will be described with reference to FIG. **5**. FIG. **5** is a side view for explaining the arrangement of a powder recoater **500** according to this embodiment. The powder recoater **500** according to the third embodiment is different from the powder recoater according to the second embodiment in that it further includes supply amount adjustment portions **501**. The remaining arrangement and operation are the same as those in the second embodiment, so the same reference numerals denote the same arrangement and operation and a detailed description thereof will not be repeated.

The supply amount adjustment portions **501** are provided below a powder supply portion **202**, and are provided between the powder supply portion **202** and a fabricating surface. By adjusting the opening of each supply amount adjustment portion **501**, the supply amount of a powder **211** to be spread to the fabricating surface can be adjusted. The supply amount adjustment portion **501** functions as a restrictor, and the supply amount of the powder **211** can be increased by increasing the opening, and decreased by decreasing the opening.

The supply amount adjustment portions **501** are arranged on the two sides of the powder recoater **500** on the advancement direction side (forward direction side) and the retraction direction side (backward direction side). The shape of the supply amount adjustment portion **501** may be a shutter-like structure or a plate-like structure, and is arbitrary as long as the drop path of the powder **211** can be closed or opened.

Powder induction portions **502** form a mechanism for inducing the powder **211** so that the powder **211** supplied from the powder supply portion **202** drops toward the supply amount adjustment portions **501**. By providing the powder induction portions **502**, the powder **211** supplied from the powder supply portion **202** can be prevented from flowing out laterally.

According to the second embodiment, the supply amount adjustment portions **501** are further arranged, and the spread amount of the powder **211** can be adjusted more finely.

Other Embodiments

The present invention has been described above with reference to the embodiments. However, the present inven-

tion is not limited to those embodiments. Various changes understandable by those skilled in the art within the scope of the present invention can be made for the arrangements and details of the present invention. The present invention also incorporates a system or apparatus that somehow combines different features included in the respective embodiments.

The invention claimed is:

1. A powder recoater comprising:

a hopper that stores a powder;

a cylindrical powder supplier that has a side surface close to or in contact with a bottom surface of said hopper and includes a supply path for the powder; and

a rotating unit that causes the powder supplier to rotate,

wherein a center axis connecting an inlet and outlet of the supply path is displaced from an axis of rotation of said powder supplier in a radial direction of said powder supplier, and

said rotating unit rotates said cylindrical powder supplier in order to bring the outlet of the supply path at a predetermined position corresponding to a traveling direction of said cylindrical powder supplier, before causing said cylindrical powder supplier to travel.

2. The powder recoater according to claim **1**, further comprising a supply amount adjuster that is provided below said powder supplier and adjusts a supply amount of the powder supplied from said powder supplier.

3. The powder recoater according to claim **1**, further comprising a smoother that smooths a spread powder, said smoother being provided below said powder supplier.

4. The powder recoater according to claim **1**, further comprising a vibrator that vibrates said hopper.

5. The powder recoater according to claim **1**, wherein said rotating unit is a servo motor.

6. A three-dimensional fabricating apparatus using a powder recoater, said powder recoater comprising:

a hopper that stores a powder;

a cylindrical powder supplier that has a side surface close to or in contact with a bottom surface of said hopper and includes a supply path for the powder; and

a rotating unit that causes the powder supplier to rotate,

wherein a center axis connecting an inlet and outlet of the supply path is displaced from an axis of rotation of said powder supplier in a radial direction of said powder supplier, and

said rotating unit rotates said cylindrical powder supplier in order to bring the outlet of the supply path at a predetermined position corresponding to a traveling direction of said cylindrical powder supplier, before causing said cylindrical powder supplier to travel.

7. The three-dimensional fabricating apparatus according to claim **6**, wherein said powder recoater further comprises a supply amount adjuster that is provided below said powder supplier and adjusts a supply amount of the powder supplied from said powder supplier.

8. The three-dimensional fabricating apparatus according to claim **6**, wherein said powder recoater further comprises a smoother that smooths a spread powder, said smoother being provided below said powder supplier.

9. The three-dimensional fabricating apparatus according to claim **6**, wherein said powder recoater further comprises a vibrator that vibrates said hopper.

10. The three-dimensional fabricating apparatus according to claim **6**, wherein said rotating unit of said powder recoater is a servo motor.

* * * * *